PATENT SPECIFICATION

DRAWINGS ATTACHED

941,813

941,813

Date of Application and filing Complete Specification Aug. 18, 1961.
No. 29932/61.

Application made in South Africa (No. 3776) on Sept. 15, 1960.

Complete Specification Published Nov. 13, 1963.

Index at acceptance:—Classes F4 U60; G2 J11B1.

International Classification:—F 24 c (G 02 d).

COMPLETE SPECIFICATION

Improved Means for Concentrating Solar Energy

I, LLEWELLYN ERNEST HUNT, of 67, Victoria Avenue, Vereeniging, Transvaal Province, South Africa, of South African Nationality, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an improved means for concentrating solar energy more particularly for the utilisation of said solar energy for the purpose of heating.

A great number of appliances utilising solar energy rely on the concentration of solar energy by suitable means, e.g. by means of a reflective surface or surfaces. A concave reflective surface curved in free dimensions for assimilating a three-dimensional curvature has hitherto been found to be most suitable and effective, as rays from all parts of the reflective surface are concentrated substantially on one point. Being curved in three dimensions, however, raises the cost considerably and in fact makes it prohibitive in some cases.

It is the object of the present invention to provide a means for concentrating solar energy easily, economically and efficiently.

It is a further object of the invention to provide a system by means of which solar energy may be projected downwards onto a point so that in the case of a melting pot or the like, the solar energy may pass into said pot or the like through the opening at the top instead of through the sides.

Further objects, advantages and applications of the invention will become apparent from the following description.

The present invention consists in a means for concentrating solar energy which comprises two systems of reflective surfaces as hereinafter defined facing each other, each of which has or produces the effect of a two-dimensional concave curvature, one system serving as a collector system and being adapted and arranged to face the sun, and the second system serving as and herein referred to as a secondary reflector system, being adapted and arranged to have its back to the sun, the two systems being arranged so that their effective focal lines are normal to one another, and in which the focal length of the collector system is greater than that of the corresponding secondary reflector system, the secondary reflector system being furthermore positioned to intercept reflected light rays from the collector system at a point located at a distance from the focal line of the collector system equal or substantially equal to the focal length of the secondary reflector system, the arrangement being such as to cause the rays of light striking the collector system to converge onto substantially one point or limited area after reflection from the secondary reflector system.

The term "a system of reflective surfaces" whenever used in this specification should be understood to mean a system adapted to reflect light rays and comprising either a single reflective surface, e.g. a mirror or an area of polished metal, or a set of reflective surfaces combined to have the effect of a single larger reflective surface, and the plural should be understood to include the singular and vice versa.

The term "a two-dimensional curvature" is intended to describe the shape of a surface of which all sections in one particular direction are rectilinear whereas all sections at an angle thereto are curved, the curvature of any two parallel sections being identical and parallel.

The effective curvature of both the systems of reflective surfaces preferably is or corresponds to a parabola.

In a particular embodiment of the invention-

tion a system of reflective surfaces may comprise a number of relatively narrow, flat reflective members placed end to end or side by side so as to approximate the effect of a continuously curved parabolic surface.

In a preferred embodiment of the invention the relatively narrow, flat, reflective members are so mounted that they may be adjusted to vary their angular position with regard to the sun in order essentially to produce the effect of a variation of the angular position of the parabola with regard to the sun as desired or required.

The secondary reflector system preferably has a parabolic curvature or the approximate effect of parabolic curvature, which is not by itself symmetric about any line of symmetry, but which is located at one side of the plane of symmetry of the complete parabola of which the secondary reflector system forms a part. This feature introduces the advantage that the focal point of the rays is positioned outside the path of the rays being reflected from the collector system to the secondary reflector system, and that no part of the secondary reflector system will present an obstacle to the rays reflected from the collector system. The secondary reflector system is preferably somewhat smaller in area than the collector system.

The collector system may be mounted upon a track or the like, said track preferably being circular so that the collector system may be rotated in accordance with the position of the sun in such a manner that it always faces the sun.

The secondary reflector system is preferably also mounted on a track or the like, so that it may be adjusted to any desired position, so that rays from the collector system are always reflected onto said secondary reflector system.

In a preferred embodiment of the invention, both the collector system and the secondary reflector system may be tilted in any direction so that a maximum concentration of rays fall onto said reflective systems.

The reflective systems may be constructed of any suitable material, e.g. metal or alloy, having a reflective surface. The reflective surfaces are preferably hardened so as to prevent damage or dulling by the elements of the weather.

In a particular embodiment of the invention, if the energy is to be used to melt metals or the like in a melting pot or the like, the reflective systems are so arranged that the rays are reflected downwards onto the melting pot or the like, so that said rays pass through the open end into said pot or the like instead of through the side walls.

In one embodiment of the invention, the melting pot may be tiltable so that the open end can always be turned towards the reflected sun rays.

The melting pot or boiler or the like is preferably stationary whilst the reflective surfaces may be moved to follow the sun.

The invention and the manner in which it may be put into practice will be further described by way of the following examples with reference to the accompanying drawings without thereby limiting the scope of the invention claimed:—

Figure 1 is a schematic perspective representation of a solar energy concentrating device in accordance with the invention,

Figure 2 shows a plan view of a solar energy concentrating device in accordance with the invention,

Figure 3 is a diagrammatic representation of a vertical section through a solar energy concentrating installation in accordance with the invention,

Figure 4 shows a plan view of an arrangement of reflective surfaces forming a collector system in accordance with the invention, such as the embodiment of Figure 3,

Figure 5 shows a plan view of a further arrangement of solar energy concentrating device in accordance with the invention,

Figure 6 is a plan view of yet another arrangement of a solar energy concentrating device in accordance with the invention.

It should be clearly understood that the drawings have not been drawn strictly according to scale.

Referring to Figure 1: Parallel rays from the sun *1* strike a concave collector mirror *2* having a two-dimensional curvature and are reflected by said collector mirror *2* onto a secondary reflector mirror *3*, which is concave and has a two-dimensional curvature, the curvature being in a plane which is substantially perpendicular to the plane of curvature of the collector mirror *2*, and said secondary reflector mirror *3* being somewhat above the collector mirror *2* and within the focal length of said collector mirror *2*, at a point located at a distance from the focal line of the collector mirror *2* equal or substantially equal to the focal length of the secondary reflector mirror *3*, and so that their focal lines are normal to one another. The rays caused to converge by the collector mirror *2*, are reflected by the secondary reflector mirror *3* and continue converging until they meet at a point *4* within a melting pot *5*. The parallel rays striking the secondary reflector mirror *3*, are caused to converge by said secondary reflector mirror *3*, the curvature of which is such that its focal length corresponds to the distance between point *4* within the melting pot *5* and said secondary reflector mirror *3*, so that the parallel rays striking the secondary reflector mirror *3* are caused to converge and meet at point *4*.

All rays striking the collector mirror *2* have thus been caused to converge into one point

by means of two mirrors each having a two-dimensional curvature.

The melting pot 5 is below the secondary reflector mirror 3 so that the rays from said secondary reflector mirror 3 fall downwards into the melting pot thus obviating the necessity for said rays to pass through the side walls of said melting pot 5.

Referring to Figure 2:

The concave collector mirror 2 with two-dimensional curvature is mounted on a support 6, which has wheels 7 by which means it runs on a track 8. The collector mirror 2 may thus be rotated on the circular track 8. The rays from the collector mirror 2 are caused to converge and strike a secondary reflector mirror 3 having an upper edge 9 and a lower edge 10, the secondary reflector mirror 3 being positioned within the focal length of the collector mirror 2, at a point located at a distance from the focal line of the collector mirror 2 equal or substantially equal to the focal length of the second reflector mirror 3. The rays converging from the collector mirror 2 strike, and are reflected by, the secondary reflector mirror 3 and continue converging until they meet at point 4 within the melting pot 5. As the sun makes its path across the sky the collector mirror 2 is rotated on rails 8 so that it always faces the sun. The secondary reflector mirror 3 is similarly rotated so that it always has its back to the sun and is in such a position that the rays reflected by the collector mirror 2 wall on said secondary reflector mirror 3.

Both the secondary reflector mirror and the collector mirror may also be tilted about a horizontal axis so as to receive the maximum concentration of sun rays.

Referring to Figure 3:

The rays from the run fall onto a set of reflective surfaces *2a*, said reflective surfaces *2a* being so arranged that they produce in combination the effect of a concave parabolic collector mirror reflecting the rays of the sun onto a secondary reflector mirror 3, said secondary reflector mirror 3 having a two dimensional curvature. The rays of the sun, which are caused to converge in one plane by the reflective surfaces *2a* forming the concave collector mirror, strike the concave secondary reflector mirror 3 by means of which they are re-reflected, their degree of convergence in that one plane, produced by the first set of reflective surfaces *2a*, remaining substantially unchanged. The rays on striking the secondary reflector mirror are in addition caused to converge by said secondary reflector mirror 3 into a melting pot 5. The mirrors are so arranged that the focal line of the secondary reflector mirror is normal or approximately normal to the focal line of the collector system of mirrors, so that the ultimate result is a focal point or an approximation thereof. The melting pot 5 is set up so that the converging rays from the secondary reflector mirror 3 upon being re-reflected will enter through opening *5a* and so that the focal point falls inside said melting pot 5. The reflective surfaces *2a* may be tilted and turned so that the maximum concentration of rays from the sun may always fall onto said reflective surfaces *2a*. As is clearly shown the secondary reflector mirror 3 has a parabolic curvature but is not by itself symmetric about any line of symmetry; it is located at one side of the plane of symmetry of the complete parabola of which the secondary reflector system forms a part, the plane of symmetry of which is given by the dot-dashed line 16.

When placed behind each other as shown in Figure 3, the reflective surfaces *2a* must be so arranged that they in no way interfere with the reflected rays of light from any of the other reflective surfaces. The reflective surfaces *2a* may be tilted and turned so as to allow the maximum concentration of sunlight to fall on them at all times.

Referring to Figure 4:

A number of reflective surfaces *2a* are mounted on concentric arcs of circles or parabolas and each surface is at such an angle to the sun and the remainder of the installation that the system of reflective surfaces produces the effect of a concave collector mirror having a two-dimensional curvature. The reflective surfaces *2a* on the arcs are mounted in such a manner that the reflective surfaces *2a* of the one arc do not interfere with the reflected rays from the reflective surfaces *2a* of any other arc. (See Figure 3). The reflective surfaces *2a* may be tilted or turned about a horizontal as well as about a vertical axis. The reflective surfaces *2a* may be turned individually about a vertical axis so that the system of reflective surfaces always produces the effect of a concave collector mirror with a two-dimensional curvature facing the sun and concentrating all collected solar energy on the secondary reflector mirror, which is, of course, also moved and turned in conjunction with the collector surfaces.

Referring to Figure 5:

A number of reflective surfaces *2a* are positioned on a straight line in such a manner that by turning and tilting the individual reflective surfaces the system of reflective surfaces always has the approximate effect of a concave collector mirror with a two-dimensional parabolic curvature facing the sun. A second line of reflective surfaces *2a* is set up behind the first and if desired or required any number of further lines may be set up. The reflective surfaces are so positioned that they do not interfere with the reflected rays from the reflected surfaces *2a* behind them, so that all rays reflected by said reflective surfaces *2a* in all the lines fall onto the secondary reflector mirror 3 having an upper edge 9 and a lower

edge *10* by means of which the rays are reflected and concentrated within the melting pot *5*.

Referring to Figure 6:

A set of reflective surfaces *2a* are mounted on a set of carriages *11*, which carriages *11* in turn run on a set of tracks *8*, said tracks *8* being circular. The individual reflective surfaces *2a* on the carriages *11* viewed in plan, are partly at a fixed angle to the tracks so that the system of reflective surfaces *2a* will produce the effect of a concave collector mirror having a two-dimensional curvature and they may further each be tilted about a horizontal axis so as to ensure that a maximum concentration of sunlight will always be reflected onto the secondary reflector mirror *3* having an upper edge *9* and a lower edge *10*, by means of which secondary reflector mirror *3* said rays are re-reflected and concentrated within a melting pot *5*. The secondary reflector mirror *3* may also be tilted about a horizontal axis so as to receive the maximum concentration of the rays from the reflective surfaces *2a* forming the collector mirror system. Both the second reflector mirror *3* and the melting pot *5* are mounted upon a carriage *12* which runs on a track *13* by means of wheels *14*. The track *13* is circular so that both the secondary reflector mirror *3* and the melting pot *5* may always be revolved whenever the system or reflective surfaces *2a* forming the collector mirror is turned, so as to ensure that the reflected rays from the reflective surfaces *2a* fall onto the secondary reflector mirror *3* and are concentrated in the melting pot *5*. The melting pot *5* is further mounted on an axis *15* so that it may be tilted so as to ensure that the rays of light reflected from the secondary reflector mirror *3* will fall into said melting pot *5*.

All figures of the drawings illustrate the secondary reflector system in such a position that its axes of curvature and therefore its optical focal line are essentially parallel to the ground.

WHAT I CLAIM IS:—

1. A means for concentrating solar energy which comprises two systems of reflective surfaces, as hereinbefore defined, facing each other, each of which has or produces the effect of a two-dimensional concave curvature as hereinbefore defined, one system serving as a collector system and being adapted and arranged to face the sun, and the second system serving as and herein referred to as a secondary reflector system, being adapted and arranged to have its back to the sun, the two systems being arranged so that their effective focal lines are normal to one another, and in which the focal length of the collector system is greater than that of the corresponding secondary reflector system, the secondary reflector system being furthermore positioned to intercept reflected light rays from the collector system at a point located at a distance from the focal line of the collector system equal or substantially equal to the focal length of the secondary reflector system, the arrangement being such as to cause the rays of light striking the collector system to converge onto substantially one point or limited area after reflection from the secondary reflector system.

2. A means for concentrating solar energy as claimed in claim 1 in which the effective curvature of both the collector system and that of the secondary reflector system, each is or corresponds to a parabola.

3. A means for concentrating solar energy as claimed in either of claims 1 and 2 in which the secondary reflector system has an effective curvature corresponding to a section of a parabola, which system is not in itself symmetric about any line of symmetry, but is located at one side of the plane of symmetry of the complete parabola of which the secondary reflector system forms a part.

4. A means for concentrating solar energy as claimed in any one of claims 1 to 3 in which one or both of the systems of reflective surfaces comprise a number of relatively narrow, flat reflective members arranged end to end or side by side so as to approximate the effect of a continuously curved parabolic surface.

5. A means for concentrating solar energy as claimed in claim 4 in which the relatively narrow, flat, reflective members are so mounted that they may be adjusted to vary their angular positions with regard to the sun in order essentially to produce the effect of a variation of the angular position of the parabola with regard to the sun as desired or required.

6. A means for concentrating solar energy as claimed in any one of claims 1 to 5 in which the secondary reflector system is of smaller area than the collector system.

7. A means for concentrating solar energy as claimed in any one of claims 1 to 6 in which the collector system is mounted upon a track, said track being circular so that the collector system may be rotated in accordance with the position of the sun in such a manner that it always faces the sun.

8. A means for concentrating solar energy as claimed in any one of claims 1 to 7 in which the secondary reflector system is mounted on a track so that it may be adjusted to any desired position so that rays from the collector system are always reflected onto said secondary reflector system.

9. A means for concentrating solar energy as claimed in any one of claims 1 to 8 in which both the collector system and the secondary reflector system are tiltable in any direction so that a maximum concentration of rays fall onto said systems.

10. A means for concentrating solar energy

as claimed in any one of claims 1 to 9 in which the energy is used to melt metals in a melting pot and the systems of reflective surfaces are so arranged that the rays are reflected downwards onto the melting pot so that they pass through the open end into the melting pot, said melting pot furthermore being tiltable so that the open top of the pot can be positioned to face the reflected sun rays.

11. A means for concentrating solar energy as claimed in any one of Claims 1 to 10 comprising the feature that the optical focal line of the secondary reflector system is parallel to the ground.

12. A means for concentrating solar energy substantially as illustrated in and by the drawings accompanying the specification.

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Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1963.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

941813 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

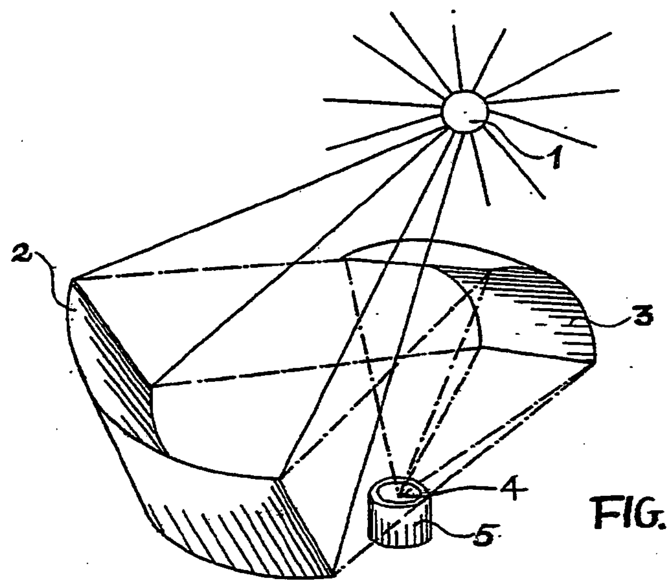

FIG. 1

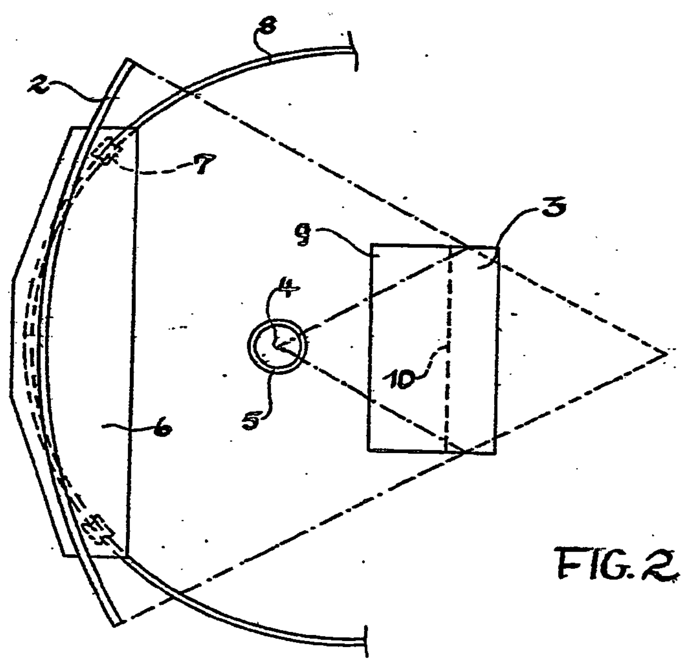

FIG. 2

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FIG. 3

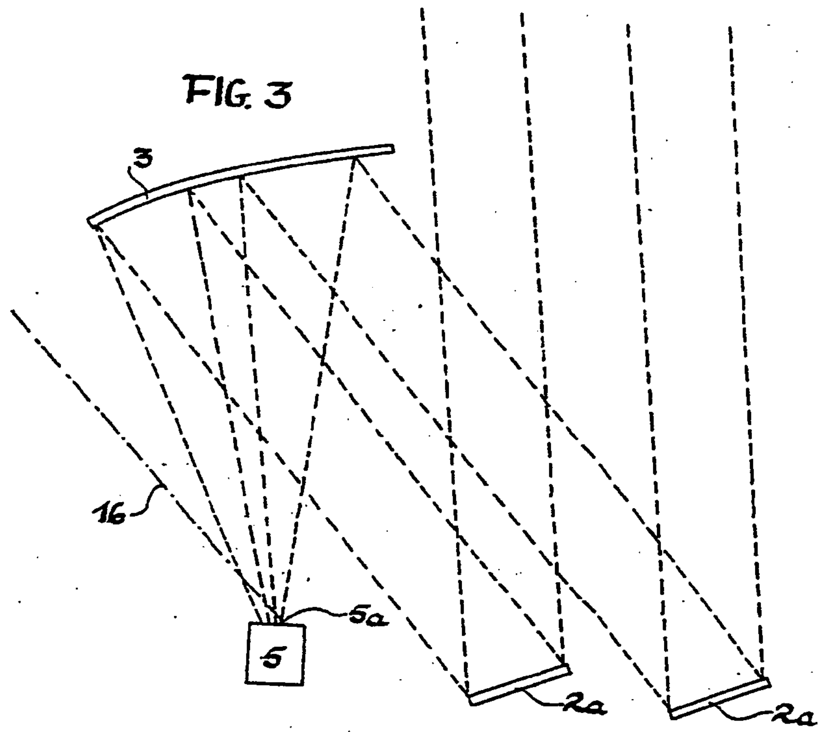
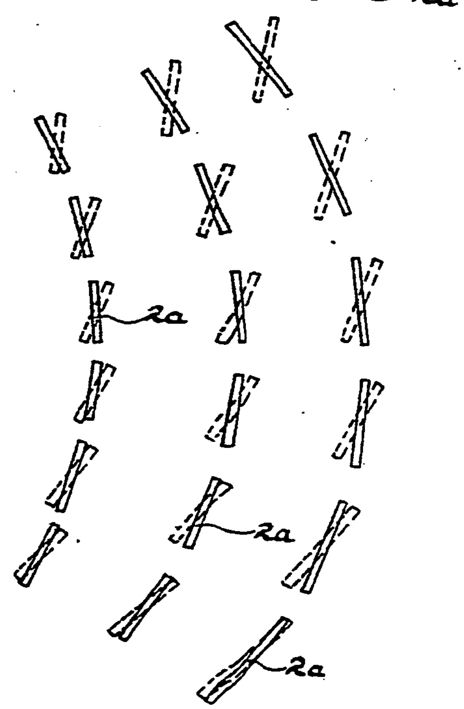


FIG. 4



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Sheets 2 & 3

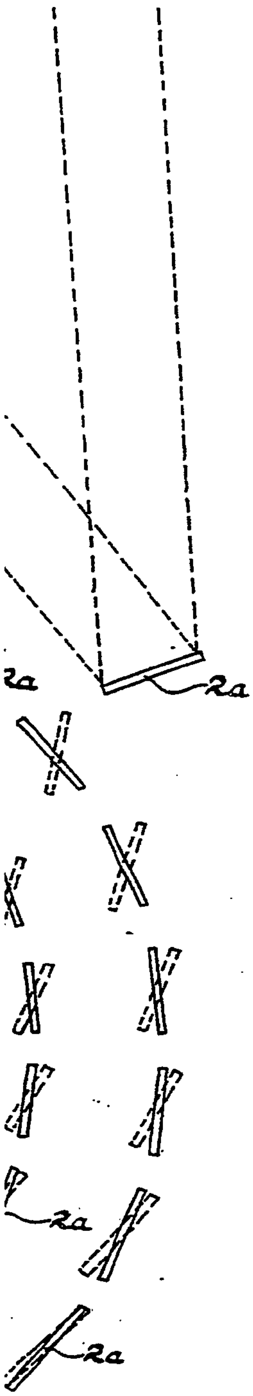
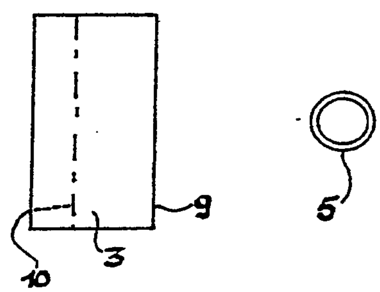


FIG. 5



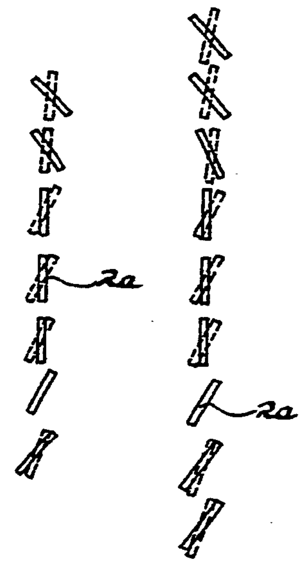
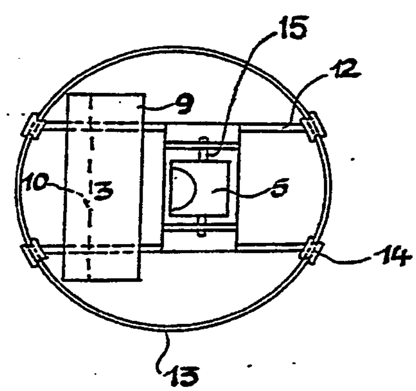
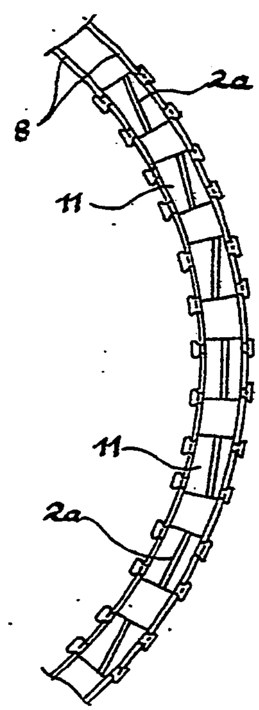


FIG. 6





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Sheets 2 & 3

FIG. 3

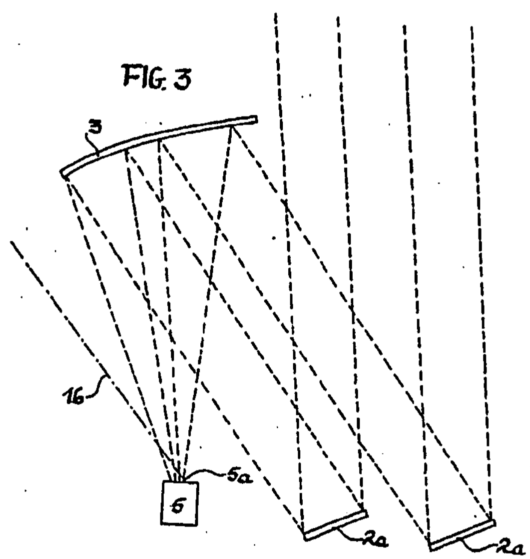


FIG. 4

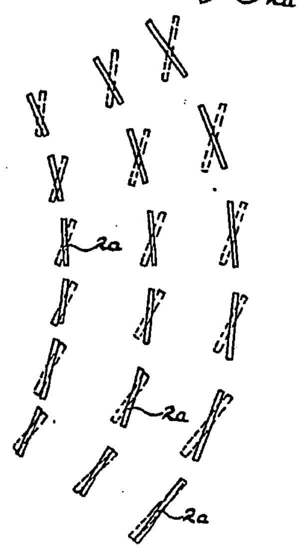
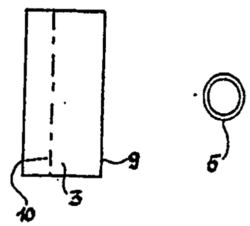


FIG. 5



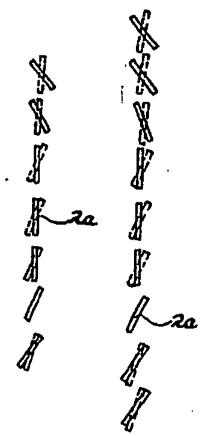
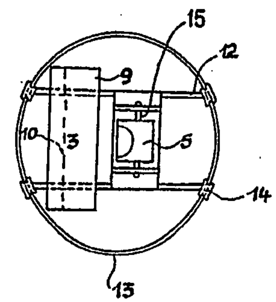
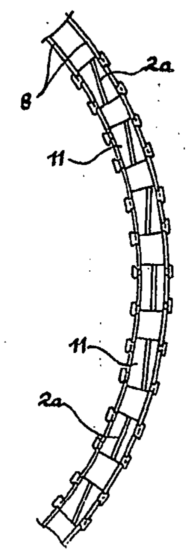


FIG. 6





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